

TITLE OF THE INVENTION  
IMAGE SENSING APPARATUS

## FIELD OF THE INVENTION

5       The present invention relates to an image sensing apparatus which senses an object image.

## BACKGROUND OF THE INVENTION

An example of the arrangement of a conventional  
10 digital still camera will be described with reference  
to Fig. 7.

In Fig. 7, when the photographer operates a camera operation switch 201 (comprised of, e.g., the main switch and release switch of a camera), an overall control CPU 200 detects a change in the state of the camera operation switch 201, and starts supplying power to other circuit blocks.

An object image within the photographing frame range is formed on an image sensing element 204 via main photographing optical systems 202 and 203, and converted into an analog electrical signal. The analog electrical signal from the image sensing element 204 is subjected to analog processing by a CDS/AGC circuit 205, converted into a predetermined signal level, and 25 converted into a digital signal for each pixel by an A/D converter 206.

A driver circuit 207 controls horizontal driving

and vertical driving of the image sensing element 204 on the basis of a signal from a timing generator 208 which determines the driving timing of the whole system. The image sensing element 204 then outputs an 5 image signal.

Similarly, the CDS/AGC circuit 205 and A/D converter 206 also operate on the basis of timings from the timing generator 208.

Reference numeral 209 denotes a selector which 10 selects a signal on the basis of a signal from the overall control CPU 200. An output from the A/D converter 206 is input to a memory controller 215 via the selector 209, and all signal outputs are transferred to a frame memory 216. In this case, all 15 pixel data of photographing frames are temporarily stored in the frame memory 216. For sequential shooting or the like, all pixel data of photographed images are written in the frame memory 216.

After the end of write in the frame memory 216, 20 the contents of the frame memory 216 which stores pixel data are transferred to a camera digital signal processor (DSP) 210 via the selector 209 under the control of the memory controller 215. The camera DSP 210 generates R, G, and B color signals on the basis of 25 pixel data of each image stored in the frame memory 216.

Before normal photographing, the generated R, G,

and B color signals are periodically (every frame) transferred to a video memory 211, obtaining a viewfinder display or the like by a monitor display 212.

5       When the photographer designates photographing (i.e., image recording) by operating the camera operation switch 201, pixel data of one frame are read out from the frame memory 216 in accordance with a control signal from the overall control CPU 200,  
10      subjected to image processing by the camera DSP 210, and temporarily stored in a work memory 213.

     Data in the work memory 213 is compressed by a compression/decompression unit 214 on the basis of a predetermined compression format. The compressed data  
15      is stored in an external nonvolatile memory 217 (generally, a nonvolatile memory such as a flash memory is used).

     To observe photographed image data, data which is compressed and stored in the external memory 217 is  
20      decompressed into normal data of each pixel via the compression/decompression unit 214. The decompressed data of each pixel is transferred to the video memory 211, allowing to observe the photographed image via the monitor display 212.

25      In this manner, in a general digital camera, an output from the image sensing element 204 is converted into actual image data via the signal processing

circuit in almost real time, and the result is output to the memory or monitor circuit.

In such digital camera system, compatibility with a silver halide film such as a 135 format film camera system is important particularly for an interchangeable lens type single-lens reflex camera.

The lens can be used as far as the mount is common. However, the photographing view angle, i.e., focal length suffers a difference in size between the 10 image sensing element and the film.

At present, the size of the image sensing element which can be manufactured at once is limited owing to the manufacturing apparatus, i.e., so-called stepper. Also in terms of cost, the image sensing element is 15 generally smaller than the film. Considering the same photographing sense as that for the film, and particularly photographing with a wide-angle lens, an image sensing element equal in size to a silver halide film is desirable.

20 As one measure, Fig. 8 schematically shows one image sensing element such as a CCD which is constituted by joining in three-dimensional exposure (to be referred to as joint exposure hereinafter).

In Fig. 8, one image sensing element is divided 25 into three, left, center, and right regions. The regions are exposed to individual masks and finally joined into one image sensing element. In Fig. 8,

joint exposure is executed in a vertical structure of a semiconductor layer, on-chip color filter layer, and on-chip microlens layer to constitute an image sensing element equal in size to the film.

5       Fig. 9 is a view for explaining a semiconductor layer when the image sensing element in Fig. 8 is a CCD. In this CCD, the charges of pixels generated in a photodiode 190 are transferred at once to vertical CCDs 191 at a predetermined timing. The charges in the  
10      vertical CCDs 191 on all lines are transferred to horizontal CCDs 192, 193, and 194 at the next timing.

In the arrangement shown in Fig. 9, the horizontal CCDs 192, 193, and 194 transfer charges to a common amplifier 195 every transfer clock. An  
15      amplified output is read out via common CDS/AGC circuits 196 and 198.

Such CCD can be used similarly to a general image sensing element as far as joint exposure is successful.

Even in the CCD of Fig. 9 which looks like a  
20      general image sensing element, a shift by joint exposure actually exists in each vertical structure of a semiconductor layer, on-chip color filter layer, and on-chip microlens layer. The output level varies between the three regions.

25       Especially, the on-chip color filter layer and on-chip microlens layer readily shift, and the influence appears as a step in the gain direction. In

particular, the on-chip color filter layer is exposed for each color, the shift varies, and the step varies between colors.

As shown in Fig. 10, the regions may twist in the  
5 plane (two-dimensionally), resulting in a very complicated shift.

#### SUMMARY OF THE INVENTION

The present invention has been made to overcome  
10 the conventional drawbacks, and has as its object to obtain a high-quality image free from any variation between image sensing regions.

To solve the above problems and achieve the above object, according to the first aspect of the present  
15 invention, an image sensing apparatus is comprising an image sensing element which is formed on a semiconductor substrate on which at least one of a semiconductor layer, a color filter layer, and a microlens layer is formed by a plurality of divisional  
20 exposure operations, and a correction device which corrects variations in a signal output from the image sensing element between a plurality of partial image sensing regions formed by the plurality of divisional exposure operations.

25 According to the second aspect of the present invention, an image sensing apparatus comprises an image sensing element on which color filters of a

plurality of colors for sensing an object image are formed, and a correction device which divides an image sensing region of the image sensing element into a plurality of partial image sensing regions, and  
5 corrects variations between the partial image sensing regions by using a different correction value for each color.

Other objects and advantages besides those discussed above shall be apparent to those skilled in  
10 the art from the description of a preferred embodiment of the invention which follows. In the description, reference is made to accompanying drawings, which form a part hereof, and which illustrate an example of the invention. Such example, however, is not exhaustive of  
15 the various embodiments of the invention, and therefore reference is made to the claims which follow the description for determining the scope of the invention.

#### BRIEF DESCRIPTION OF THE DRAWINGS

20 Fig. 1 is a block diagram for explaining the arrangement of a digital camera according to the first embodiment of the present invention;

Figs. 2A to 2D are views for explaining block division according to the first embodiment of the  
25 present invention;

Fig. 3 is a table for explaining a correction value table according to the first embodiment of the

present invention;

Fig. 4 is a view for explaining an expanded correction value table according to the first embodiment of the present invention;

5 Fig. 5 is a block diagram for explaining the arrangement of a digital camera according to the second embodiment of the present invention;

Figs. 6A to 6C are views for explaining a correction value table according to the second 10 embodiment of the present invention;

Fig. 7 is a block diagram for explaining the arrangement of a conventional digital camera;

Fig. 8 is a view for explaining joint exposure;

15 Fig. 9 is a view for explaining a semiconductor image sensing element by joint exposure; and

Fig. 10 is a view for explaining an example of a shift by joint exposure.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

20 An image sensing signal correction method and image sensing apparatus according to preferred embodiments of the present invention will be described in detail below with reference to the accompanying drawings.

25 (First Embodiment)

Fig. 1 is a block diagram showing an image sensing apparatus (digital camera) according to the

first embodiment of the present invention.

This image sensing apparatus is basically constituted by adding a block correction unit 6 and a correction nonvolatile memory 7 for storing a 5 correction value to the arrangement of Fig. 7.

In Fig. 1, reference numeral 1 denotes an image sensing element which is driven and controlled similarly to a general element though the image sensing element 1 is constituted by joint exposure. The image 10 sensing element 1 is driven by a driver 2 and operates at a predetermined frequency. A timing generator 3 is a timing generation circuit which outputs a vertical sync signal VD and horizontal sync signal HD. The timing generator 3 simultaneously supplies timing 15 signals to circuit blocks.

A pixel signal from the image sensing element 1 is input to a CDS/AGC circuit 4, and subjected to processing such as known correlated double sampling to remove reset noise contained in an output from the CCD 20 or the like. The output is amplified to a predetermined signal level. The amplified pixel signal is converted into a digital signal by an A/D converter 5, thus obtaining a digital pixel signal.

The digital pixel signal is sent to the block 25 correction unit 6 where a shift by joint exposure is corrected. The block correction unit 6 loads a correction value for each block from the correction

nonvolatile memory in accordance with an instruction from an overall control CPU, and performs correction (to be described later) for the digital pixel signal in accordance with a timing signal from the timing generator 3.

Information of a photographing lens 20 is transferred to an overall control CPU 18 via a mount 19 (camera & lens mount). To switch a correction value for each block by the photographing lens, the overall control CPU 18 sends an instruction to this effect to the block correction unit 6. This will also be described later.

The corrected pixel signal is input to a memory controller 10 via a selector 8, and all signal outputs are transferred to a frame memory 11. In this case, all pixel data of photographing frames must be temporarily stored in the frame memory 11. For sequential shooting or the like, all pixel data of photographed images are written in the frame memory 11.

After the end of write in the frame memory 11, the contents of the frame memory 11 which stores pixel data are transferred to a camera digital signal processor (DSP) 9 via the selector 8 under the control of the memory controller 10. The camera DSP 9 generates R, G, and B color signals on the basis of pixel data of each corrected image stored in the frame memory 11.

When the photographer designates photographing (i.e., image recording) by operating a camera operation switch 17, pixel data of one frame are read out from the frame memory 11 in accordance with a control signal 5 from the overall control CPU 18, subjected to image processing by the camera DSP 9, and temporarily stored in a work memory 13.

Data in the work memory 13 is compressed by a compression/decompression unit 15 on the basis of a 10 predetermined compression format. The compressed data is stored in an external nonvolatile memory 16 (generally, a nonvolatile memory such as a flash memory is used).

To observe photographed image data, data which is 15 compressed and stored in the external memory 16 is decompressed into normal data of each pixel via the compression/decompression unit 15. The decompressed data of each pixel is transferred to a video memory 12, allowing to observe the photographed image via a 20 monitor display 14.

The arrangement of Fig. 1 assumes that the burden of signal processing in the camera DSP 9 is not increased. If the system has a margin for signal processing in the camera DSP 9, shift correction may 25 also be performed in the camera DSP.

Correction of a shift caused by joint exposure will be explained.

As described above, an on-chip color filter layer and on-chip microlens layer readily shift, and the influence appears as a step in the gain direction. In particular, the on-chip color filter layer is exposed  
5 for each color, the shift varies, and the step varies between colors.

To solve this problem, the first embodiment executes correction with a correction value obtained by storing or calculating in advance a correction value  
10 for each block which subdivides a divided exposure region and includes a plurality of pixels.

Figs. 2A to 2D are views for explaining division into blocks.

As shown in Fig. 2A, the image sensing element undergoes joint exposure at two, right and left joints, and one image sensing element is constituted by joining three, left, center, and right regions. As shown in Fig. 2B, the image sensing element is divided into a plurality of blocks by using the right and left joints  
15 as division boundaries. In this case, the image sensing element is divided into six in the vertical direction x 11 in the horizontal direction. Blocks as shown in Fig. 2C are formed from the entire image sensing element, and serve as a correction value table.  
20 The first embodiment adopts a correction value corresponding to each color of the on-chip color filter. For example, for a general Bayer filter, a  
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correction value table having four planes is prepared, as shown in Fig. 2D.

As the number of blocks increases, the precision is considered to increase. However, this increases the 5 memory area of the system, and thus the number of blocks must be determined in consideration of the balance with the effect.

The form of the correction value will be explained.

10 The correction value is one in the gain direction. Pixel signals on two sides at a joint are multiplied by correction values so as to eliminate any steps at the right and left joints.

15 As correction values to be obtained, the first embodiment obtains correction values in the right and left regions by using as a reference a signal in a divided exposure region including the optical axis of a photographing optical system, i.e., the central region in this embodiment.

20 This is because the center of the frame is designed to be directly used. The center of the frame often provides an object to be observed, and is determined to be kept unchanged in order to fully exploit the performance of the image sensing optical 25 system.

A shift is so corrected as to eliminate any step at a joint. This purpose is primarily achieved. In

other words, other portions are processed by other correction operations. An independent correction value is used in the boundary direction at the joint, and the same correction value as that at the end of the  
5 boundary is used in a direction perpendicular to the boundary direction.

From this viewpoint, one correction value table is shown in Fig. 3.

In Fig. 3, all correction values in the central  
10 region are 1. In the right and left regions, blocks along each joint are assigned values optimal for them. In a direction perpendicular to the joint (horizontal direction in Fig. 3), the same correction value as that of a block along the joint is set. With this setting,  
15 even if, e.g., the peripheral light quantity changes at the periphery, a natural change can be maintained.

The correction value is switched for a target lens when a shift cannot be satisfactorily corrected unless the correction value is changed owing to, e.g.,  
20 the pupil distance or F-number of a photographing lens.

Fig. 4 is a view for explaining this. Especially in an interchangeable lens for a single-lens reflex camera system, the pupil distance changes depending on the focal length. To cope with this, three correction  
25 values are prepared for a standard lens, telephoto lens, and wide-angle lens, and stored in the correction value nonvolatile memory. When the photographing lens

20 is mounted on the camera, an optimal correction value table is sent to the correction calculation region of the block correction unit 6 on the basis of lens identification information (lens ID) obtained via 5 the mount 19. Satisfactory shift correction can always be achieved.

Instead of changing the correction value on the basis of the lens ID as information on a mounted lens, the correction value may be changed or calculated on 10 the basis of information on the pupil distance or F-number.

(Second Embodiment)

In the first embodiment, the read system of the image sensing element 1 has only one channel. In the 15 second embodiment, a read system capable of high-speed read has two channels.

Fig. 5 is a block diagram showing an image sensing apparatus (digital camera) in which the read system of an image sensing element 1 has two channels.

20 Since importance is placed on high-speed processing, two CDS/AGC circuits 4-1 and 4-2 and two A/D converters 5-1 and 5-2 are added to the block diagram of Fig. 1.

The image sensing element 1 adopts various read 25 methods by the two systems. Signals may be read out divisionally from right and left regions at the center of the element surface, as disclosed in Japanese Patent

Laid-Open No. 2000-253305 as shown in Fig. 6A.

Instead, signals may be alternately read out every line (Fig. 6B). Signals may be read out by subdividing the region within the image sensing element, and  
5 multiplexed into two channels in externally outputting the signals (Fig. 6C).

In these cases, a shift generated by the difference in read system must be coped with.

The measure changes depending on a combination  
10 with the arrangement of an on-chip color filter. For example, when the Bayer array is employed, the methods in Figs. 6A and 6B can be realized even by one set of block correction tables.

The method of Fig. 6C requires two sets of block  
15 correction values unless the shift between a plurality of systems is corrected by any method. This is because a shift occurs between the two read channels even with the same color of the on-chip color filter.

As described above, according to the first and  
20 second embodiments, the signal difference between a plurality of regions can be corrected when the image signal region of an image sensing element in an image sensing apparatus is formed by joint exposure and the sensitivity becomes nonuniform in the two-dimensional  
25 direction.

Even if nonuniformity changes depending on the optical factor of a photographing optical system such

as the exit pupil position or F-number, a signal difference can be more properly corrected.

In read by many systems, the signal difference between a plurality of regions including the shift 5 between a plurality of read channels can be corrected.

The above embodiments can obtain a high-quality image free from any variation between image sensing regions.

The present invention is not limited to the above 10 embodiments and various changes and modifications can be made within the spirit and scope of the present invention. Therefore, to apprise the public of the scope of the present invention the following claims are made.